

Attachment A

**Kentucky Bluegrass Post-Harvest
Straw-Based Particleboard**

Phase 1 Report

Kentucky Bluegrass Post-harvest Straw-based Particleboard

Phase 1 Report
to
Washington State Department of Ecology

December 1996

C. W. (Bill) Russell
AGB Technologies, Inc.
Regina, Saskatchewan
Canada

W. J. Johnston
Dept. of Crop & Soil Sciences
Washington State Univ.
Pullman, WA

Technical Report No. 9608-07
Department of Crop and Soil Sciences
Washington State University
Pullman, WA 99164-6420

Kentucky Bluegrass Post-harvest Straw-based Particleboard

December 1996

**C. W. (Bill) Russell
AGB Technologies, Inc.
Regina, Saskatchewan
Canada**

**W. J. Johnston
Dept. of Crop & Soil Sciences
Washington State Univ.
Pullman, WA**

Contents

EXECUTIVE SUMMARY.....	5
Section 1: INTRODUCTION.....	7
1.1 Literature Search.....	7
1.2 Market Analysis	7
1.3 Straw Evaluation.....	7
1.4 Procurement Considerations	8
1.5 Survey Questionnaire	9
1.6 Observations and Recommendations	9
Section 2: LITERATURE SEARCH.....	10
Section 3: MARKET ANALYSIS.....	12
3.1 General Product Description	12
3.2 The North American Particleboard Industry.....	13
3.3 Environmental Benefits	15
3.4 The Strawboard Advantage	16
Section 4: STRAW EVALUATION.....	18
4.1 Bluegrass Acreage	18
4.2 Biomass Estimates	19
4.3 Screen Analysis	22
4.4 Cleaning Mill Residues.....	23
4.5 Additional Fiber Sources	24
Section 5: PROCUREMENT CONSIDERATIONS.....	26
5.1 Type of Baler.....	26
5.2 Storage.....	26
5.3 Contract Baling.....	27
Section 6: SURVEY QUESTIONNAIRE	28
Section 7: CONCLUSIONS AND RECOMMENDATIONS.....	33
APPENDIX ONE: SAMPLE PANEL TEST RESULTS.....	35
LITERATURE CITED	37

CHARTS AND TABLES

Chart 1: DEMAND/CAPACITY FORECAST.....	14
Chart 2: COST/PRICE FORECAST.....	14
Table 1: BLUEGRASS ACRES, WASHINGTON.....	18
Table 2: BLUEGRASS ACRES, IDAHO.....	18
Table 3: HOOP TEST RESULTS.....	20
Table 4: RESIDUE ANALYSIS.....	20
Table 5: ESTIMATED BLUEGRASS STRAW YIELDS.....	22
Table 6: MILLED STRAW SCREEN ANALYSIS.....	23
Table 7: ESTIMATED VOLUME OF PLANT SCREENINGS.....	24
Table 8: ESTIMATED TOTAL GRASS FIBER VOLUME.....	24
Table 9: ESTIMATED WHEAT AND BARLEY VOLUME.....	25
Table 10: SAMPLE PANEL TEST RESULTS.....	36

EXECUTIVE SUMMARY

This project has been designed to provide a preliminary basis for further study to evaluate the potential to use post-harvest crop residue from Kentucky bluegrass to produce industrial quality particleboard.

As a Phase 1 component of a larger study, this report addresses initial project design, an overview of the product markets, fiber volume analysis (including the design of a grower questionnaire), and recommendations for procedures to be involved in Phase 2.

The environmental pressures on the Kentucky bluegrass (*Poa pratensis* L.) industry in the eastern Washington/northern Idaho region are mounting dramatically, and solutions need to be identified that represent real and pragmatic options for growers and conditioners.

It is the premise of this report that the potential to use bluegrass straw as a feedstock for industrial particleboard represents a substantial component of such an option.

With timber cut-backs and fiber constraints, the traditional sources of materials for wood-based particleboard are quickly disappearing. This is producing an increased pressure on conventional fiber sources, for both price and availability. At the same time the marketplace demand for particleboard is the highest in history, and is forecast to continue, exerting a squeeze on the industry's capacity to meet the demand through the rest of the decade.

All U.S.-made particleboard currently uses wood and a toxic binder (urea formaldehyde). A straw-based panel using bluegrass straw (or a combination of bluegrass and cereal straw) and a non-formaldehyde polymeric resin, PMDI (polymeric dyphenolmethane diisocyanate) can produce a water-resistant panel that is stronger, non-toxic, and environmentally-friendly.

The total U.S. particleboard consumption for 1996 is projected to rise to 5.73 bsf (billion square feet – 3/4" thickness), an increase of 54% over 1991. This would be the third straight year in which record consumption levels for particleboard have been set. A significant amount of this consumption, nearly 15%, will need to be filled by imports, since the current U.S. capacity of approximately 5.07 bsf is unable to meet the demand. It should be noted that the capacity of a plant designed to utilize a sustainable volume of bluegrass straw (based on current volume levels) would represent less than 10% of the import volume.

It is an underlying assumption of this report that a particleboard plant dependent on agricultural residues needs to be small, and located close to its raw materials. Large straw bales are high volume/low weight packages and the cost of shipping could become prohibitive if long distances and great volumes are involved.

The straw capacity in the bluegrass growing area of eastern Washington and northern Idaho is estimated at 40,000 to 50,000 tons of straw annually. A compact strawboard plant in the region, designed to utilize this much fiber per year, would have a capacity to produce approximately 30 million square feet of 3/4" thick product per year, at a capital cost of approximately \$13 million. This will not only create a new straw market for growers of over \$2 million per year, but also provide 35 to 40 new jobs with a direct payroll of nearly \$1.5 million.

In other words, bluegrass straw can be used to produce a high-quality industrial product, creating a fiber market that could have a substantial impact on open-field burning of bluegrass post-harvest residue.

Section 1: INTRODUCTION

The scope of work originally developed for this feasibility analysis included the following components:

1.1 Literature Search

A detailed review will be conducted to assess previous research on particleboard manufacturing, including non-wood systems, as well as the specific uses of agricultural residues for commercial conversion applications. Particular emphasis will be placed on the unique acquisition and handling concerns of bluegrass straw. Study criteria will be determined from this review, and possible adaptations which may be required for an Inland Empire endeavor will be identified. Sources will be identified for both information as well as validation of findings.

1.2 Market Analysis

A general market analysis will review the current state of the particleboard industry in North America. This will be detailed enough to identify possible areas for industrial panel applications, as well as value-added manufacturing which might be suitable for a bluegrass straw product. In order to establish a basis for qualifying other components of the study, a limited degree of actual marketplace interviews will be conducted.

In addition to the particleboard market, a review of possible other uses for bluegrass straw will be conducted. This will assess both known and potential commercial conversion applications, and provide a basis for further straw assessment.

1.3 Straw Evaluation

An understanding of grass straw availability and composition is essential in order to make a qualified business development decision. This phase will involve the following elements:

Biomass Assessment – Biomass ratios will be determined for Kentucky bluegrass, as well as for wheat and barley. The resulting biomass findings will provide a conversion formula for forecasting sustainable residue volumes on a crop-by-crop basis in the region.

Harvest/Handling Practices – There are enough variations in farming practices and equipment to significantly impact the potential for economic residue accumulation and acquisition. Present cultural practices such as harvesting, baling, field burning, storage, and transporting need to be identified in order to assess their suitability for particleboard production. In conjunction with this evaluation, the affect of certain types of equipment on the physical characteristics of straw needs to be assessed.

Straw Assessment – In order to determine the processing requirements for grass straw, a quantity of fiber will be collected and prepared. A general evaluation of specific soil types and baling/procurement methods will be made, to ensure that finished sample properties can be defined within an appropriate context. An analysis of the geometric parameters of straw will be made, with comparative assessment with known particleboard fiber parameters.

This phase will result in a detailed documentation of sample batches, including species, cultivars, location, and soil types, in order to provide a basis for further evaluation. A screen analysis of processed straw components will also be included. Lab analyses for fiber, lignin, and ash will be done.

1.4 Procurement Considerations

Procurement Parameters – There are a variety of scenarios for gathering straw for a commercial operation. Based on preliminary interviews, a list of criteria will be developed to identify key procurement parameters. This will include an evaluation of storage limitations of baled straw, and identify possible options. This assessment will also assist in the questionnaire design.

Industry Participation – Several grass seed cleaning facilities in the Inland Empire will be approached to determine the suitability of utilizing cleaning plant residues for particleboard production.

1.5 Survey Questionnaire

In anticipation of conducting an extensive grower survey in Phase 2, a questionnaire will be designed regarding grower assumptions and expectations on straw pricing, baling, on-farm storage, and transportation. Information on types of equipment and other farming practices, such as field burning and suitable length of time between harvest and straw pick up will also be addressed. In order to best develop an effective survey questionnaire, a series of grower focus group sessions will be conducted prior to the distribution of the survey. The actual grower survey will be conducted as an integral part of Phase 2.

1.6 Observations and Recommendations

The determination to proceed with Phase 2 can be made based on this report.

Section 2: LITERATURE SEARCH

While straw has been used as an additive for building materials since the time of Moses, its use as a primary industrial feedstock has never been fully developed. In 1974, Oregon State University completed a four-year study into the use of ryegrass straw as particleboard furnish, which established the use of polyurethane binders as a suitable resin¹. No significant commercial enterprise emerged from this study, however.

In 1986, the government of the Canadian province of Saskatchewan undertook a two-phase, three-year study into the use of the province's vast wheat residues for industrial particleboard². This led to the establishment of certain technological improvements, utilizing recent chemical and equipment developments. Much of the present international interest in straw-based particleboard has grown from these Canadian developments.

The fundamental findings from these early efforts have clearly demonstrated that agricultural residues of all kinds can be used for composite panel manufacture. Successful laboratory testing has confirmed that wheat, barley, bluegrass, sawdust, and various blends of these fibers are suitable for particleboard³.

Although the typical wood-based panel plant is relatively large -- often capable of producing 150 million to 300 million square feet annually -- a successful strawboard plant should be small (approximately 30 million square feet capacity), and located close to raw material supplies⁴. The primary adaptation to conventional processing relates to the bonding agent. The urea formaldehyde resin used in wood panels is ineffective with cereal straws, due to the inhibiting factor of the exterior wax coating on the straw¹. With straws, the use of polyisocyanate resin has proven to not only produce a stronger, water-resistant bond, but is formaldehyde-free.

There is presently one manufacturing facility in North America which produces industrial particleboard from wheat straw⁵. Several other studies are underway in the western United States and Canada, all of which focus on the use of cereal straws.

At present, there is a noticeable lack of documentation on the gathering and handling of bluegrass residues^{6,7,8,9}. Since the traditional practice has been to open-field burn the straw after harvest, no significant market for straw has been developed. Given the present legislation in the state of Washington which might eliminate open-field burning following the 1998 grass harvest, there is now a renewed interest in baling and handling.

Section 3: MARKET ANALYSIS

3.1 General Product Description

"Particleboard" belongs to a family of composition boards typically composed of wood elements of varying sizes and held together by an adhesive bond. Plywood, waferboard, oriented strand board (OSB), medium density fiberboard (MDF), and hardboard are all composite products.

The manufacture of composition boards includes two important steps: the processing of larger fiber components into smaller elements or particles (a reduction process), and the recombination of these products into sheet form (a lamination process). The various types of board differ mainly by the size and shape of the strands, wafers, or particles used. In plywood, for example, the "particles" are actually thin veneer sheets with consistent dimensions that can be assembled and laminated without densification. Waferboard and oriented strand board (OSB) are composed of thin wafers which have been randomly sliced from blocks of timber. The typical OSB strand has a somewhat greater width-to-length ratio than waferboard, permitting the strand to be more consistently directionally aligned in layers throughout the panel. This orientation creates a stronger finished panel, which can compete favorably with plywood in structural panel applications.

Particleboard is based on particles that are very small compared to veneer sheets or wafers. Their dimensions are irregular and they are generally assembled in a random fashion. Glue line contacts and development of mechanical properties depend less on fiber bulk or length than on densification of the finished panel. In all composition boards, it has been found that an increase in board density results in more intimate contact between the particles and improves most physical properties. Also, resin can be lost in the interparticle voids in lower-density panels. If a board is compressed to higher density, more of the resin is used effectively. Increasing board density not only increases resin effectiveness, but also causes more fiber to be present to resist mechanical loads. This combination normally results in greater board strength. As discussed later, particleboard utilizing straw can achieve greater strength properties

without depending as much upon high density levels. This can be an advantage in some product applications.

3.2 The North American Particleboard Industry

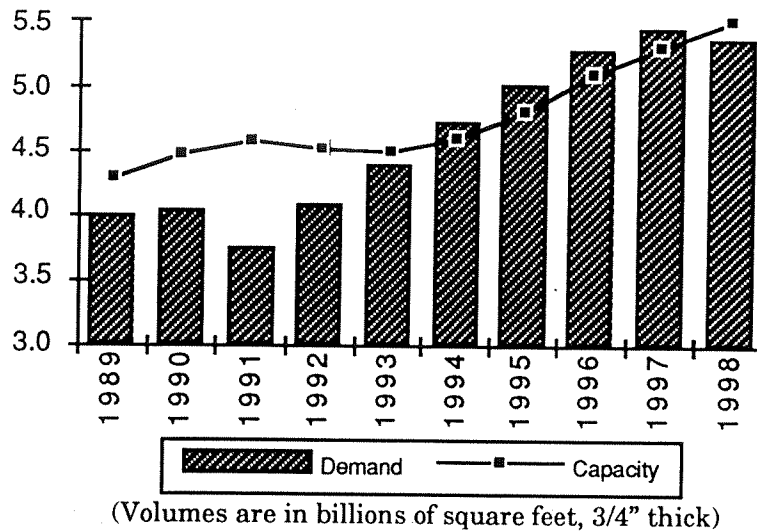
Several factors are creating a steady increase in North American particleboard consumption, including lower interest rates, healthy home construction, and increasing use of panel products in the furniture sector. This increase is expected to continue for several years, setting new records for particleboard demand.

North American mills are not expected to be able to keep up with this increased demand. This is partially due to the timber harvest cutbacks which in turn reduce the traditional sources of fiber, namely wood chips, planer shavings, and sawdust from sawmills and plywood mills. It is possible that even with the record setting demands, some particleboard mills may be forced to close over the next few years due to fiber shortfalls.

Capacity increases in the particleboard industry are only expected to be incremental to existing plants for the next few years, in areas where sawmill residues are still available. Whereas, slight increases in the South and East (5% to 6% per year) are forecast through 1998, net capacity losses are assumed in the West as mills are unable to find sufficient raw materials.

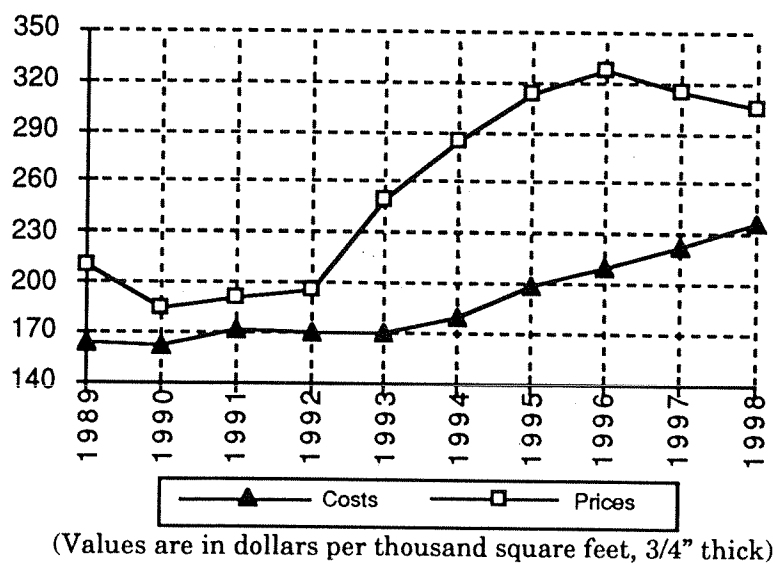
The following chart depicts the estimated relationship between particleboard demand and the capacity of the industry to meet that demand.

CHART 1: Demand/Capacity Forecast



With the rise in both production costs and demand, prices are expected to also rise to record-setting levels. While this will produce the best profit potential that the particleboard industry may have ever seen, it will be somewhat offset by the higher wood costs. By 1996, the price of particleboard is conservatively expected to be over 50% higher than the 1990 low. The Cost/Price Forecast chart below shows the forecast relationship between particleboard prices and manufacturing costs through 1998.

CHART 2: Cost/Price Forecast



The total consumption of particleboard in the U.S. is forecast to rise to 5.73 billion square feet (bsf) (3/4" basis) by 1996, a 54.8% increase over the 1991 volume of 3.70 bsf. Over 80% of this amount will be used in furniture (both household and office) and cabinets.

Traditionally, cabinets and furniture were made from high grades of plywood with clear veneer faces. Due to the dwindling log supplies, however, most of the furniture and cabinet panels (referred to as "industrial" panels) are now made with a particleboard or medium density fiberboard (MDF) core, or substrate, with either a solid veneer surface or one of several types of paper laminate overlays.

In the general industry today, and for the foreseeable future, composite panel products like particleboard, MDF, and now strawboard, will only increase their share of the industrial markets. There are no economical substitutes for such products.

3.3 Environmental Benefits

The potential to manufacture industrial particleboard from agricultural residues carries with it significant environmental implications. In a general sense, one benefit can be seen in the lessening of the pressures on competitive wood fiber supplies, presently becoming extreme in some areas where board plants and pulp mills compete for the same limited raw materials. By developing alternative agricultural feedstocks for composition boards, the best and highest value for wood fibers can then be attained.

A second environmental benefit comes from the product itself. By eliminating urea formaldehyde binders from the panel, straw particleboard can be used in high-risk areas such as mobile homes, medical centers, and public institutions.

Particleboard made from agricultural residues are not merely environmentally-friendly – they can be used to reduce if not eliminate health hazards associated with conventional panels.

The benefits associated with the use of bluegrass straw for particleboard will mirror the advantages noted above. In addition, the establishment of an industrial market for grass straw will directly affect the specific concerns surrounding the field burning of bluegrass residue.

3.4 The Strawboard Advantage

There are several advantages to using straw-based particleboard as opposed to wood particleboard.

3.4.1 Product Advantages

- **Stronger** -- laboratory test samples, made under simulated plant conditions, exceed American National Standards for every property criteria tested.
- **Water-resistant** -- the chemical bonding system produces a dimensionally stable product which is resistant to moisture fluctuations and swelling.
- **Non-Toxic** -- straw particleboard does not use urea-formaldehyde binders, and produces no toxic emissions.

3.4.2 Environmental Advantages

- **Safer** -- with no formaldehyde, straw particleboard is chemically inert.
- **Environmentally Friendly** -- with growing public concerns over the environment, straw particleboard represents a viable substitute for wood-based panels. Potential reduction in open-field burning emissions.
- **Other Biomass Potential** -- able to convert to other cellulose materials, including urban wood wastes, logging trash, mill wastes, etc.

3.4.3 Marketing Advantages

- **More Responsive to Markets** -- a smaller board plant can respond quickly to changing customer requirements.
- **Engineered Products** -- a compact facility can engineer and produce specialty panels for unique end uses.
- **Shipping Benefits** -- the initial market for straw particleboard can focus on the extensive furniture manufacturing sector in the U.S. mid-west. By targeting special customer requirements, especially light-weight panels, shipping the finished product becomes a less critical costing factor.

3.4.4 Economic Advantages

- **Rural Economic Impact** -- annual local payroll and straw purchases can exceed \$4 million; the total regional economic impact can surpass \$10 million a year.
- **Job Creation** -- a straw particleboard plant can directly employ 35 to 40 people, with potential for many more through added-value production.
- **Low Capital Cost** -- under \$15 million per plant.
- **Profit Potential** -- potential to earn substantial after-tax income.

3.4.5 Other Advantages

- **Closer to Raw Materials** -- in most agricultural zones, the annual straw requirements can be supplied within a one or two hour haul from the plant.
- **Agricultural Diversification** -- there are presently no sustainable commercial markets for agricultural plant residues; a straw particleboard plant can create a new market for straw.
- **Research & Development** -- the first plant in an area can become a showcase for new product development, representing not only a domestic R&D facility but a substantial technology transfer potential to both developed and emerging countries.

Section 4: STRAW EVALUATION

The primary consideration in any strawboard plant development is the sustainable supply of straw. In order to determine the potential for a strawboard plant in the eastern Washington/northern Idaho area, the total availability of bluegrass straw has been estimated. Recoverable biomass estimates have also been made.

4.1 Bluegrass Acreage

The table below shows the bluegrass acreage reported by the Washington State Department of Agriculture, from 1986 to 1995.

TABLE 1: Bluegrass Acreage, Washington Counties

County	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
	Acres									
Spokane	15,100	21,500	24,600	24,400	23,800	20,700	18,500	20,000	24,000	22,500
Whitman	3,200	3,500	3,600	3,400	3,300	3,600	3,400	4,500	4,400	3,800
Garfield	3,900	5,100	7,000	5,200	4,800	4,500	3,000	3,700	4,000	3,000
Walla Walla	700	2,500	2,900	3,000	2,700	2,300	1,200	1,500	2,100	2,000
Adams	na	700	2,700	3,000	2,700	na	na	2,200	2,400	2,300
Other	400	1,000	1,700	3,000	2,700	2,900	2,900	3,100	2,100	2,900

The following data reflect the reported acreage from Kootenai and Benawah Counties in northern Idaho, from 1992 to 1996. Since the primary region of irrigated land is in the Rathdrum Prairie area of Kootenai County, the irrigated acreages are noted.

TABLE 2: Bluegrass Acreage, Idaho Counties

County	1992	1993	1994	1995	1996
	Acres				
Kootenai (irrigated)	9,236	10,162	9,552	10,360	8,941
Kootenai (dryland)	6,955	10,458	12,567	13,870	15,873
Benawah	4,375	5,278	5,824	4,552	5,820

4.2 Biomass Estimates

In order to assess a cross-section of bluegrass straw from the region, samples were collected in several areas. Field samples are identified by numbers:

- #1: Collected on farm of Wayne Meyer, approximately one mile south of Rathdrum, Idaho along Highway #41 in Kootenai County; irrigated, level land; 'Kenblue' common cultivar; average stubble was relatively high, 6" to 10", with considerable patches of longer stubble due to heavy lodging; all samples collected were from level ground, on mixed Avondale silt loam/Garrison gravel soil.
- #2: Collected on farm of John Cornwall, approximately seven miles west of Rockford, Washington, on Fleming Road two miles south of Valley Chapel Road in Spokane County; 'Kenblue' common cultivar; average stubble approximately 4" to 5"; dryland field, very hilly, on Larkin silt loam soil of dark topsoil on heavy clay base; samples were collected from east-facing slope, hill tops, northwest facing slope, and bottom of slope.
- #3: Collected on farm of Larry Gady, five miles northeast of Rockford, Washington, on Harvard Road one-half mile south of Elder Road, in Spokane County; moderately hilly, dryland field, on Freeman soil (minimal topsoil, heavy clay); samples were collected from hilltop, northeast slope, and southwest slope.

"Hoop tests" were conducted to gather residue samples in order to provide a reasonable estimate of potential straw weight per acre. A 36"-diameter cable hoop was placed at random on a stubble field and all loose straw within the hoop was gathered. In these tests, no clipping of stubble was involved. All straw was collected in sample bags, weighed, oven dried, and reweighed. Percent moisture in the residue was 3.8%, 5.3%, and 7.0% at

the Cornwall, Meyer, and Gady sites, respectively. The net weight of the straw, in grams, was multiplied by 20 to determine the estimated weight in pounds per acre. The hoop tests were replicated several times per field, and the average of all tests used to estimate potential residue tons per acre.

TABLE 3: Hoop Test Results

Field	Sample	Soil Type	Slope Location	Weight (gms)	Weight (pounds)	Average (per acre)
1	A		Level	303.0	6060	
	B		Level	172.7	3454	
	C		Level	527.0	10540	
	D		Level	521.2	10424	
	E		Level	468.9	9378	
	F		Level	202.9	4058	7319
2	A		NE	227.0	4540	
	B		NE	123.3	2466	
	C		Hilltop	286.3	5726	
	D		SE	401.1	8022	
	E		SE	218.2	4364	
	F		Bottom	295.2	5904	5170
3	A	Freeman	Hilltop	265.6	5312	
	B	Freeman	NE	370.6	7412	
	C	Freeman	Hilltop	464.8	9296	
	D	Freeman	SW	170.0	3400	6355

TABLE 4: Residue Analysis

Kentucky bluegrass residue analysis.

Neutral Detergent Fiber	90.68 %	Total ash	4.29 %
Acid Detergent Fiber	55.51 %	ODM	90.7 %
Acid Detergent Lignin	8.77 %		
Acid Insoluble Ash (Si*)	0.79 %		

Analysis based on one sample made from a composite of subsamples from Cornwall, Meyer, and Gady sites at WSU NRS Wildlife Habitat Laboratory.

* Assumed to be mostly Si.

In order to assess the potential for a grass-straw particleboard plant in a specific region, the data above have been evaluated to determine whether a reasonable conversion formula can be defined. Assuming that the average

weight per acre in the preceding table is representative of recoverable straw in the region, the amount from irrigated land (sample #1) is approximately 3.6 tons per acre, while dryland amounts would be approximately 2.5 to 3.1 tons per acre.

However, several factors need to be considered in order to determine a realistic estimate for recoverable fiber. These factors include the following:

- The favorable 1996 growing conditions (good moisture) produced a heavier than normal straw volume;
- Normal baling functions will produce some fiber loss, estimated at 15 to 20% of total recoverable biomass;
- The hilly land in much of Spokane County will prohibit the effective operation of balers;
- Field burning is still permitted in Idaho, and some producers there will likely continue to prefer open-field burning;
- Anecdotal testimony from producers, conditioners, and academic sources have been consistent for a "rule-of-thumb" average of 1 to 1.5 tons per acre on dryland, and 2 to 3 tons per acre on irrigated land.

It is the purpose of this report to determine a reasonable basis for forecasting straw tonnage, which would be available for commercial feedstock on a sustainable basis. It is therefore expedient to seriously consider all areas in which straw may not be available for procurement, even though these may be the reported tonnage on the land. A conservative estimate of net recoverable fiber would therefore discount the hoop test averages by the following assumptions:

- Less 10 to 15% to reflect a normal production year's residue;
- Less 15 to 20% to reflect inaccessible slopes;
- Less 20 to 25% to reflect non-participation by Idaho producers;
- Less 15 to 20% to reflect baling loss.

(It should be noted that these are only estimates and will need to be confirmed through further analysis during Phase 2.)

This would produce the following estimates:

- Dryland: 0.5 to 1.0 tons per acre
- Irrigated: 0.7 to 1.4 tons per acre

Assuming a conservative working estimate of 0.75 ton per acre for dryland, and 1 ton per acre for irrigated land, the following straw volumes can be estimated. These estimates assume that a reasonable hauling distance for a Spokane County plant site would be approximately fifty miles, and involve only Spokane County in Washington and Kootenai and Benawah Counties in Idaho. Figures stated are only for those years in which comparative data were available.

TABLE 5: Estimated Straw Yields

County	1992	1993	1994	1995
		Tons		
Spokane	13,875	15,000	18,000	16,875
Kootenai (irrigated)	9,236	10,162	9,552	10,360
Kootenai (dryland)	5,216	7,844	9,425	10,403
Benawah	3,281	3,959	4,368	3,414
Totals	31,609	36,964	41,345	41,052

4.3 Screen Analysis

Particle geometry of straw samples were processed by performing screen analysis at the Washington State University Wood Materials and Engineering Lab to determine the suitability for mechanical fractionation. The samples were hammermilled using a 1/8" round-hole screen, and separated in a sieve shaker using various mesh sizes.

TABLE 6: Milled Straw Screen Analysis

Kenblue	#1	1.5%	15.2%	45.9%	17.8%	14.1%	5.2%
Kenblue	#2	1.5%	22.7%	40.1%	18.0%	13.1%	4.7%
Kenblue	#3	3.2%	27.5%	40.3%	15.9%	10.3%	3.0%
Sample "S"	---	10.4%	26.3%	35.4%	14.5%	9.0%	4.4%
Sample "P"	---	4.3%	18.1%	38.5%	17.4%	14.0%	7.2%
KBG Aver.	---	4.2%	21.9%	40.0%	16.7%	12.1%	4.9%
Cereal Av.	---	19.8%	28.6%	24.8%	11.7%	8.6%	6.2%

The range of particle sizes demonstrated by this analysis clearly shows that bluegrass straw is highly adaptable for use as a particleboard feedstock. By achieving this range of fractions, a percentage of both fine materials (42 mesh and smaller) and coarse fiber (32 mesh and larger) can be processed.

4.4 Cleaning Mill Residues

When bluegrass seed is delivered to the cleaning plant, it contains a significant amount of contaminants, including chaff, stems, leaves, and small particles of broken straw. This is typically separated from the seed in the cleaning process and converted into pellets for cattle feed. Estimates of the volume of this non-seed fiber range from 40% to 60% of the total delivered seed.

Phase 2 evaluation will assess the suitability of blending this fiber with longer straw particles for use in particleboard. The preliminary assumption is that it represents a usable source of fiber, and the seed cleaning companies have indicated their interest in making this fiber available.

Using a conservative assumption that 40% of delivered seed will represent useful fiber, potential feedstock estimates can be made. For forecast

purpose, a yield figure of 450 pounds of seed per acre for dryland, and 800 pounds per acre for irrigated land, is used in the following calculation.

TABLE 7: Estimated Volume of Plant Screenings

County	1992	1993	1994	1995
	Tons of screenings			
Spokane	1,665	1,800	2,160	2,025
Kootenai (irrigated)	3,694	4,065	3,821	4,144
Kootenai (dryland)	1,565	2,353	2,828	3,121
<u>Benawah</u>	<u>984</u>	<u>1,188</u>	<u>1,310</u>	<u>1,024</u>
Totals	7,99	9,405	10,119	10,314

When combined with the straw estimates, the total bluegrass fiber available for removal and use as particleboard furnish is estimated over the four-year data period as follows:

TABLE 8: Estimated Total Fiber Volume

County	1992	1993	1994	1995
	Tons of total fiber (straw + screenings)			
Spokane	15,540	16,800	20,160	18,900
Kootenai (irrigated)	12,930	14,227	13,373	14,504
Kootenai (dryland)	6,781	10,197	12,253	13,523
<u>Benawah</u>	<u>4,266</u>	<u>5,146</u>	<u>5,678</u>	<u>4,438</u>
Totals	39,517	46,369	51,464	51,365

As identified in previous studies, a compact board plant would produce approximately 30 million square feet of product per year. A plant this size would require 45,000 to 50,000 tons of feedstock. This is certainly a reachable target based on the discounted estimates of total available fiber.

4.5 Additional Fiber Sources

Previous studies have documented that various fibers can be blended together to produce strawboard. It is intended, as part of the Phase 2 analysis, to assess the suitability of mixing cereal straws with bluegrass in order to augment the total fiber supplies. Given the uncertainty of sustained bluegrass acreage in the region, it will be critical for a plant developer to ascertain on-going fiber sources.

Much study already exists as to the use of cereal straws in particleboard manufacture. In Spokane County alone, wheat and barley production is significantly higher than bluegrass, and most farmers who harvest bluegrass seed also harvest wheat and/or barley. The table below represents the long-term acreage and estimated straw tonnage for cereal crops in Spokane County.

TABLE 9: Estimated Wheat and Barley Volumes

WHEAT	1986	1987	1988	1989	1990	1991	1992	1993	1994
Acres	108,000	97,500	89,600	126,000	111,000	80,500	102,000	114,000	118,000
Weight (Tons)	311,429	353,808	366,267	364,694	433,966	232,999	285,314	390,906	310,316
BARLEY									
Acres	69,500	60,700	50,000	52,000	37,000	46,000	38,000	30,000	30,000
Weight (Tons)	192,529	193,390	21,600	176,904	112,687	156,492	88,236	103,680	74,520
COMBINED									
Weight (Tons)	503,958	547,198	387,867	541,598	546,653	389,491	373,550	494,586	384,836

Section 5: PROCUREMENT CONSIDERATIONS

There has been only minimal baling of bluegrass straw in the region, historically, and none on a sustained basis. Several discussions were held with growers and conditioners to determine areas where further assessment will be required. Several critical considerations have been identified.

5.1 Type of Baler:

A particleboard operation would normally require straw to be delivered in large square bales, typically 4' x 4' x 9' in size. It is possible to also deliver straw in large round bales, but a consistent format is preferred for more efficient plant operations. Several producers are baling straw this season (1996) in Washington due to the one-third reduction in burning acreage, and more useful evidence will be available as a result of these efforts. Two concerns already identified include the following:

- Restricted access for balers on hilly ground; and
- Reduced viability of bale due to shorter straw from rotary combines.

The slope conditions have already been identified in the straw discount assumptions in the previous section, although more assessment will be needed to refine these assumptions. As to the straw length from rotary combines, some adjustments to the thrashing function is possible, which can lengthen the straw without affecting seed yield or operating times.

5.2 Storage

Due to the normal rainfall in the region, it is likely that all bales will have to be covered during storage. Several small storage sites will have to be utilized prior to final delivery of baled straw to the plant, and tarps can be used in these locations if permanent cover (e.g. - pole barns or large sheds) is not available. Longer-term storage at the plant site will have to be designed as part of the construction design.

5.3 Contract Baling

Due to the seasonal timing of the bluegrass harvest, it is likely imperative that straw be removed as soon as possible from the fields. Coupled with the on-going harvest pressures of cereal crops, most growers will not be able to consider baling their own straw. It is, therefore, probable that the best solution to straw procurement will be through an independent contractor, capable of coordinating the baling and removal of bales from fields, storage, and transportation to the plant.

These considerations have been designed into the draft questionnaire form in the following section, which will be further refined in Phase 2 and will serve to identify producer expectations in these areas.

Even though adequate fiber supplies in the region have been identified, it is still of utmost importance that all procurement considerations be clearly identified prior to plant development. Without a sustainable and economic supply system for feedstock, a straw-dependent manufacturing facility cannot succeed.

Section 6: SURVEY QUESTIONNAIRE

As part of the Phase 2 study, a survey will be conducted with grass growers in eastern Washington and northern Idaho. The following questionnaire draft has been reviewed by several growers, conditioners, and academic sources, and reflects a preliminary approach to several considerations already identified.

Prior to distribution, further input will be sought through a focus group of interested parties. Following the compilation of data, the same group will be asked to review the findings and participate in the development of a list of criteria for pricing, procurement, and handling of straw.

It is also anticipated that potential straw contractors may be identified as a result of this process.

The questionnaire will be mailed out to all producers, likely using the mailing lists of the Intermountain Grass Growers' Association and seed cleaning operators in the region. In order to assure confidentiality, no numbering or other identification will be used on the forms. A postcard reminder will be sent out to all recipients following two weeks, and a response of 50% or higher is expected.

Kentucky Bluegrass Straw Survey

THIS IS A PRIVATE, CONFIDENTIAL QUESTIONNAIRE and these forms contain no identification codes, names, or numbers of any kind. **Your participation in this survey is very important to us**, and your responses cannot be traced. **Your honest answers are greatly appreciated.**

Instructions

Please read each question carefully, and check the box next to the choice that best describes your answer. If a question does not apply to your operation, check the "not sure" box. On questions asking for a percentage response, please estimate as closely as possible.

SECTION 1: General information about your current crop practices

1. How many acres of the following crops did you harvest in the past four years?

Year	Bluegrass	Wheat	Barley
1.1 1995	_____	_____	_____
1.2 1994	_____	_____	_____
1.3 1993	_____	_____	_____
1.4 1992	_____	_____	_____

2. How long do you keep your bluegrass crop in?

- 2.1 Less than 3 years
 2.2 4 years
 2.3 5 years
 2.4 More than 5 years
 2.5 Not sure

3. What percentage of your land is classified as "highly erodible"?

3.1 Approximately _____ %.

- 3a. What percentage of your land is irrigated?

3a.1 Approximately _____ %.

4. What is your normal practice in handling loose straw after harvest? Please indicate your best estimate of the percentage of acres for each category.

	Bluegrass	Wheat & Barley
2.1 Plow into soil _____ %	_____ %	
2.2 Bale for self	_____ %	_____ %
2.3 Bale for sale	_____ %	_____ %
2.4 Burn in field	_____ %	_____ %
2.5 Other (_____)	_____ %	_____ %

5. If burning bluegrass straw is removed as a management tool, what do you feel would be your options?

- 5.1 Bale and remove
- 5.2 Mechanical residue removal
- 5.3 Flaming
- 5.4 Reduced fuel load burning
- 5.5 Planting other crops
- 5.6 Shorter rotations
- 5.7 Other

SECTION 2: Would you sell loose straw in your field?

6. If there was a commercial market for straw, would you be interested in selling your straw in the field if someone else (e.g. a custom baler) baled and removed it?

Bluegrass

- 6.1 Yes
- 6.2 No
- 6.3 Not sure

Wheat & Barley

- 6.1.a Yes
- 6.2.a No
- 6.3.a Not sure

7. If you answered "yes" to question 6, how frequently would you sell your straw?

Bluegrass

- 7.1 Every year
- 7.2 Every other year
- 7.3 Every three years
- 7.4 Not sure

Wheat & Barley

- 7.1.a Every year
- 7.2.a Every other year
- 7.3.a Every three years
- 7.4.a Not sure

8. What do you feel would be a fair price for your loose straw?

- 8.1 Approximately \$_____ per ton.

9. How many acres of straw in the field would you be willing to sell?

- 9.1 Approximately _____ acres of bluegrass straw
- 9.2 Approximately _____ acres of wheat and barley straw

10. How soon after harvest would you need the straw to be removed?

Immediately

- 10.2 Within one week
- 10.3 Within two weeks
- 10.4 Within one month
- 10.5 Not sure

Bluegrass Wheat & Barley

10.1

11. How likely would you be to sign a long-term contract (e.g.-3-5 years) to supply a specified amount of straw to an industrial user?

- 11.1 Very likely
- 11.2 Somewhat likely
- 11.3 Not very likely
- 11.4 Very unlikely
- 11.5 Not sure

SECTION 3: Would you be interested in baling your own straw?

Note: an industrial purchaser of straw would prefer large square bales, but for purposes of this survey, large round bales will also be considered. Small square bales will not be acceptable.

12. Would you be interested in baling your own straw?

- 12.1 Yes
- 12.2 No
- 12.3 Not sure

13. What do you feel would be a fair price for baling your own straw? *(This would include the cost of both the straw and the baling.)*

13.1 Approximately \$_____ per ton.

14. What type of baler would you use?

- 14.1 Large square baler
- 14.2 Large round baler

15. Would you be interested in storing baled straw on your land on a temporary basis (e.g. 6 months)?

- 15.1 Yes
- 15.2 No
- 15.3 Not sure

SECTION 4: Other Information

16. In which of the following age groups are you included?

- 16.1 Under 25
- 16.2 25-34
- 16.3 35-44
- 16.4 45-54
- 16.5 55-64
- 16.6 65 and over
- 16.7 Choose not to answer

17. In which State/county do you farm?

State _____ County _____

18. Please add any additional comments which you feel may be helpful.

THANK YOU FOR YOUR CO-OPERATION

Section 7: CONCLUSIONS AND RECOMMENDATIONS

This Phase 1 Report was intended to identify specific concerns that need to be addressed, in order to consider a particleboard operation based on the utilization of bluegrass straw.

Several observations can be identified as a result of this preliminary assessment:

1. Nonwood fibers, including cereal and bluegrass straw, can be used to produce an industrial quality particleboard.
2. The North American market is experiencing growth in particleboard consumption, and a straw-based panel represents a premium product for the marketplace.
3. There is adequate bluegrass straw in Spokane, Kootenai, and Benawah counties to sustain a compact strawboard plant. Some augmentation from cereal straws may be needed on an occasional basis.
4. Further analysis is needed in order to determine straw baling, handling, and procurement criteria.
5. The establishment of a particleboard plant in Spokane County would provide a viable market for bluegrass straw. Since Washington growers will soon be required to remove their straw by means other than burning, a commercial use for the straw represents a significant opportunity.

Since the scope of this study has been focused on potential industrial development, it is not expected to address directly the problems created by the imposed ban on field burning. However, the availability of bluegrass straw will be directly affected by the pressures from regulators and the public to eliminate smoke from open-field burning. It is an observation by

the authors of this report that a stringent reduction, and eventual elimination, of acres burned may not be the only, or best, solution to the problem. The health concerns attributed to grass smoke results allegedly from the particulate and gas emissions from field fires. Assuming that up to 80% or more of the straw can be removed by baling, it would follow that a comparative reduction in emissions would result from burning the remaining stubble. Stubble burning -- augmented if needed by mechanical flaming -- could in many cases satisfy the growers requirements and also significantly reduce the amount of emissions.

No substantive data on comparative emissions from full-load burning and stubble/flaming burning of bluegrass was found during the course of this analysis. Research is lacking under the climatic, edaphic, and biotic conditions of eastern Washington and northern Idaho. In the opinion of the authors, such data would be invaluable in determining the viability of reductions based on particulate emissions as opposed to a straight reduction in acres burned.

APPENDIX ONE:

Sample Panel Test Results

Although not included in the original Scope of Work, some limited laboratory panel samples have been produced and analyzed since the initial draft of this report was completed. The samples were produced at the Washington State University's Wood Materials and Engineering Laboratory.

Panels were produced from Kentucky Bluegrass straw gathered near Fairfield in Spokane County, and near Pullman in Whitman County. Separate series of tests were conducted using both samples.

In addition, two other fiber blends were evaluated. As identified during the Phase One study, substantial volumes of cleaning plant screenings may be available for a potential strawboard plant. Accordingly, screening samples were supplied by Cenex Supply and Marketing of Spokane, and sample panels were produced which blended 40% screenings with 60% milled bluegrass straw. These were homogenous, that is non-layered, samples, in which all the fiber was randomly distributed throughout the panel profile.

The study also identified the possibility that a successful plant would have to depend on some volume of wheat straw to augment the supply of bluegrass straw. This consideration is particularly relevant in light of the planned reduction of grass field burning in the State of Washington. Samples were made using approximately 50% wheat straw (in the face layers) and 50% grass straw (in the core layer).

The tables below represent the results of these tests and the relevant ANSI standards for various panel grades and applications. The samples were analyzed for the following properties:

MOR: Modulus of Rupture, rating the breaking strength of the sample

MOE: Modulus of elasticity, a stiffness rating

IB: Internal Bond, rating the strength through the vertical profile of the sample

TABLE 10: Sample Panel Test Results

Straw Type	MOR	MOE	IB
Fairfield Cty	3,000	505,000	63
Whitman Cty	2,790	464,000	70
Bluegrass (core Wheat (face)	3,060	433,000	74
40% screenings 60% straw	3,540	509,000	56

ANSI A208.1	MOR	MOE	IB	Application
M-1	1,595	250,200	58	Underlay, furniture
M-2	2,103	326,300	65	Underlay, furniture
M-3	2,393	398,900	80	Furniture, cabinets, countertops, mouldings, stair treads
M-S	2,103	275,600	58	Cabinets
D-2	2,393	398,900	80	Mobile Home Decking
D-3	2,820	449,600	80	Mobile Home Decking

LITERATURE CITED

REFERENCES FROM SECTION TWO

1. Groner, R.R. and Barbour, J.F. 1973. The polyisocyanate straw particleboard process. Report prepared by Department of Agriculture Chemistry. Oregon State University. Corvallis, OR.
2. Russell, C.W. 1987. *Straw Particleboard*. Report prepared for Saskatchewan Department of Agriculture, Regina, SK.
3. Russell, C.W. 1995. Technical and economic feasibility analysis for proposed strawboard plant. Grangeville, ID.
4. Russell, C.W. 1996. *The Straw Resource: A New Fiber Basket?* Presentation presented at International Particleboard/Composite Materials Symposium, T.M. Maloney (ed.) Washington State University. Pullman, WA
5. Russell, C.W. 1994. Technical and economic feasibility analysis for proposed strawboard plant. Whapeton, ND.
6. Morrison, K.J and Law, A.G. 1978. Grass seed production. Cooperative Ext., College of Agric., Wash. State Univ. EB 704.
7. Johnston, W.J. and Golob, C.T. 1994. Kentucky bluegrass post-harvest residue management project 1992-1993. Washington State Univ. Dept. of Crop & Soil Sci., Washington State Department of Ecology Report.
8. Johnston, W.J. and Golob, C.T. 1995. Kentucky bluegrass post-harvest residue management project 1993-1994. Washington State Univ. Dept. of Crop & Soil Sci. Tech. Rep. No. 9511-34.
9. Johnston, W.J. and Golob, C.T. 1996. Kentucky bluegrass post-harvest residue management project 1994-1995. Washington State Univ. Dept. of Crop & Soil Sci. Tech. Rep. No. 9605-11.

OTHER SOURCES

American Society for Testing and Materials. 1994. *Annual Book of ASTM Standards, Section 4: Construction*. American Society for Testing and Materials. Philadelphia, PA.

- Fuller, B. [various years and reports]. Resource Information Systems, Inc., Bedford, Mass.
- Fuller, B. 1996. Particleboard/MDF Markets Quarterly (Jan.). [Carts 1 and 2, cited on p. 14 of current Phase 1 Report].
- Groner, R.R. and Barbour, J.F. 1971. Straw particleboard, an engineering and economic analysis. Report prepared by Department of Agriculture Chemistry. Oregon State University. Corvallis, OR.
- Groner, R.R. and Barbour, J.F. 1972. Particleboard made from straw/wood blends Report prepared by Department of Agriculture Chemistry. Oregon State University. Corvallis, OR.
- Maloney, T.M. 1993. *Modern Particleboard and Dry Process Fiberboard Manufacturing*. Miller Freeman Publications. San Francisco, CA
- National Particleboard Association. 1993. *American National Standard for Particleboard*. ANSI A208.1-1993. National Particleboard Association. Gaithersburg, MD
- Russell, C.W. 1987. *Straw Particleboard: Phase 2*. Report prepared for Saskatchewan Department of Agriculture, Regina, SK.
- Russell, C.W. 1995. Laboratory trials for strawboard production for furniture applications. Washington State University Wood Materials and Engineering Lab. Pullman, WA
- Sandlund, R. 1995. USDA, Crops and Soil Conservation, Grangeville, ID. September. Personal communication.
- Sarkanen, K.V. and Ludwig, C.H. 1972. *Lignins: Occurrence, Formation, Structure and Reactions*. John Wiley & Sons. New York. pp. 45, 66, 74, 189.
- Sauter, S.L. 1995. *Developing High-Quality Composites from Urban Waste, Wood and Wheat Straw Using Urea-Formaldehyde Resin*. M.Sci. Thesis. Washington State University, Department of Mechanical and Materials Engineering. Pullman, WA.
- Various editors. 1984. *National Resource Can.* Vancouver, BC.
- Washington Agricultural Statistics. [various years]. Washington Agricultural Statistics Service. Olympia, Wash.

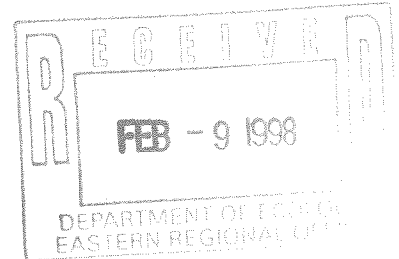
**A. PROJECT TITLE: *Post Harvest Straw-Based Particleboard:
Phase Two***

1.) **Submitted to:** Agricultural Burning Practices & Research Task Force

2.) **Funding:** First Year \$22,500.00

3.) **Project Contact:** Jon Booker, Secretary/Chairman
Sun Straw Fiber, L.L.C. UBI# 601-802-222
NW 105 Wawawai Rd.
Pullman, WA 99163

4.) **Project Coordinator:** Jon Booker, Secretary/Chairman
Sun Straw Fiber, L.L.C.
NW 105 Wawawai Rd.
Pullman, WA 99163



5.) Major Participants:

Mark Whitmore
Vice-President
Sun Straw Fiber L.L.C.
7022 SR 27
Pullman, WA 99163
(509)334-9761

Bill Russell, Consultant
AGB Technologies, Inc.
3206 25th Avenue
Regina, Saskatchewan
Canada S4S 1L4
(306) 721-3382

Keith Kopf
President
Sun Straw Fiber L.L.C.
6952 SR 270
Pullman, WA 99163
(509)872-9480

6.) Cooperators:

Randy Bostrum
Port Manager
Port of Whitman County
105 W. Island St.
Colfax, WA 99111
Phone (509)397-3791

Mike Wolcott
Associate Professor
WSU, Wood Mat & Eng. Lab
3632 Teare Rd.
Moscow, ID 83843
Phone (509)335-6392

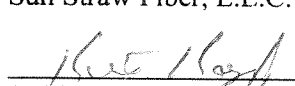
Dennis Roe
Tri-State Research Technology
WSU, Johnson Hall Rm. 201
Pullman, WA 99163
Phone (509)335-2858

Tim King
RC & D Coordinator
Upper Columbia RC & D
N. 1101 Argonne Rd.
Spokane, WA 99212
Phone (509)353-2187

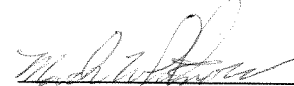
Harry W. Lee
President
Clearwater RC&DC
P.O.Box 9576
Moscow, ID 83843
Phone (208)882-2411

Vicki Rosgen
District Manager
Palouse Conservation District
325 NW State St.
Pullman, WA 99163
Phone (509)332-4101

7.) **Signatures:** I certify to the best of my knowledge that the information in this application is true and correct and that I am legally authorized to sign and submit this application on behalf of Sun Straw Fiber, L.L.C.


Keith Kopf, President

2/9/98
Date


Mark Whitmore, V. Pres.

2-9-98
Date

15

B. PROJECT SUMMARY

Due to the recent public, environmental and regulatory pressures placed on open-field burning, there is a need to develop viable alternatives for farmers. Sun Straw Fiber, L.L.C., a recently formed company of local agriculturists, is submitting a proposal, Post Harvest Straw-Based Particleboard: Phase Two, to complete a feasibility study. This will evaluate marketing and installation of a straw-based particleboard plant in the Palouse region. This project would provide new job opportunities and economic stimulation for the community as well as a cleaner environment.

This new industry will provide farmers with the option of removing straw fiber from their fields without burning. Bales will then be delivered to a particleboard plant for an added value to their operations. This will be accomplished without reducing the conservation residue levels needed to protect soils. The study targets no-till, reduced tillage and bluegrass operations. This allows farmers to continue to grow bluegrass as a viable industry. Without this alternative, bluegrass acreage will be returned to conventional tillage operations.

According to farmers in the Palouse, after harvest there is an excess of grain straw of 1-3 tons per acre depending upon production levels. Assuming that up to 80% of this straw can be removed by baling on the slopes of less than 15% grade, the need to burn would greatly be minimized. This is a significant portion of acreage presently contributing to the burn issue.

In 1996, it was estimated that 33,000 acres of straw were burned in Whitman County alone (Fitzsimmons, Spokesman Review, April 5, 1997). The smoke from this field burning has allegedly contributed to the health concerns that are troubling our urban communities. Therefore, as the results of the feasibility study are implemented, a means of reducing the number of acres burned will occur offsetting the negative health affects.

The feasibility study will address the following objectives: (2.1) Conduct Producer Survey, (2.2) Conduct Fiber Evaluation, (2.3) Conduct Laboratory Panel Testing and Sample Production, (2.4) Evaluate Equipment and Plant Concept Design, (2.5) Determine Environmental Outcomes of Fiber Production, (2.6) Produce Financial Forecasts, (2.7) Produce Final Report and (2.8) Coordinate Public Education and Information Dissemination. Upon completion of the objectives we will be ready to enter the final phase of implementation (Phase Three), installing the straw-based particleboard plant.

The strength of this proposal is two-fold: 1) a reduction in emissions and particulate matter, and 2) a practical method of straw removal farmers can utilize in their operations that includes an economic incentive. The impacts on air, water and soil will be incorporated into the study. In conclusion, if straw removal is achieved without burning we can help satisfy both the environmental and agricultural concerns.

C. PROJECT NARRATIVE

1. Project Background

Due to the recent public and regulatory pressure to place a ban on open-field burning, a need has developed to find viable alternatives for the growers. We feel the availability of bluegrass and cereal grain straw for the production of straw-based particleboard may be one answer as to a viable alternative. It is currently estimated that 2 million tons of straw residues are produced annually in Whitman County. The need for straw removal will increase as the right to burn decreases. This proposal is requesting funds to complete a feasibility study conducted by Sun Straw Fiber L.L.C. in conjunction with Bill Russell of AGB Technologies, Inc., (refer to vitae). This will evaluate the potential of developing a straw-based particle strawboard plant in the Palouse region, where the need is prevalent.

It is an observation by our group that a stringent reduction and eventual elimination of acres burned may not be the only, or best, solution to the problem. The health concerns attributed to the smoke from field burning allegedly came from particulate and gas emissions from field fires. It has been determined that in the high production areas, there is an excess of grain straw of 1-3 tons per acre. Assuming that up to 80% of the straw can be removed by baling the straw on slopes less than 15% grade for this process, it would follow that a reduction in emissions and particulate matter would result.

There will be a two-fold benefit from this process. By removing 80% of the residue through baling, growers would be able to utilize more no-till and/or reduced tillage operations. There would be decreased need for deep-plowing or burning. Following that, straw will not be harvested from slopes that are 15% grade or more, erosion prevention in place at the time will not be affected. This, in turn, would not only reduce emissions and particulate matter, but also reduce wind and water erosion. The stubble and residue left after baling would increase the organic matter and microbial activity of the soil benefiting the grower ten-fold.

The straw particle board technology involved in this feasibility study integrates the environmentally sound practices outlined above with an equally environmentally friendly board-making process. With a move from the "industry standard" of using urea formaldehyde as a binder for particleboard to using a non-toxic, emission-free PMDI, (polymeric dyphenolmethane diisocyanate) resin. Any and all materials used in this process can be re-processed; there is no *waste by-product*.

Long-term Environmental and Community Goals:

- ✓ **Develop viable alternatives to burning:** The process of using bluegrass and cereal grain straw to make particleboard will utilize the straw allowing the grower to continue their operations without burning. This process will also provide an added source of income from the sale of the straw. This will act as an incentive not to burn.
- ✓ **Reduce wind and water erosion:** By removing only 80% of the straw from the fields, there will be adequate residue left in the fields to help reduce erosion. The straw procurement process does not remove the entire residue. Ninety percent of the chaff left by the combine and the remaining stubble not taken by baling will remain on the ground. This will create more ground cover to capture snowfall and allow for less exposed soil to be blown away by the wind. Along with the remaining 20% of straw, 100% of the root mass will be left in the soil. Leaving the root mass in the soil and on top of the soil profile will add stability and structure to the soil helping to wave off erosion caused by heavy rainfall or intense tillage.

- ✓ **Provide an incentive to do more no-till and/or reduced tillage options:** One of the reasons that cereal grain growers burn the stubble is to allow reseeding of the ground to another crop without requiring intensive tillage operations to deal with large amounts of stubble. By removing 80% of the straw for the particleboard process, these growers will be able to accomplish this without burning or intensive tillage. By baling the straw for this process or allowing someone to bale for them, these growers will be adding a source of income to their operation. The strawboard company will purchase the baled straw from them, which in turn adds value and income to their operations.
- ✓ **Promote this process to interested parties and/or individuals:** We will accomplish this through mailings, media, flyers, brochures and informational seminars open to the public.
- ✓ **Reduce emissions and particulate matter from burning:** With the removal of straw by baling, the grower will not need to burn the straw. Removing 80% of the straw from the field by baling will create a real-time reduction of emissions and particulate matter as a result of not burning.
- ✓ **Job creation and economic stimulation:** A strawboard plant would initially employ 35 to 40 full-time workers year around. With an annual payroll of \$1.5 million, this would significantly increase the tax base.

2. Related and Current Work in the Area

While straw has historically been used as an additive, its use as a primary industrial feedstock has never been fully developed. In 1974, Oregon State University completed a four-year study into the use of ryegrass straw as a base material for particleboard. This study established the use of polyurethane binders as a suitable resin. A result of this study has lead to new research in Canada.

In 1986, the government of the Canadian province of Saskatchewan undertook a two-phase, three-year study into the use of the province's vast wheat residues for industrial particleboard. This led to the establishment of certain technological improvements, utilizing recent chemical and equipment developments. Much of the present international interest in straw-based particleboard has grown from these Canadian developments.

The fundamental findings from these early efforts clearly demonstrate that agricultural residues of all types can be used for composite panel manufacturing. Successful laboratory testing has confirmed that wheat, barley, bluegrass, sawdust and various blends of these fibers are suitable for particleboard.

There is presently one manufacturing facility in North America that produces industrial particleboard from wheat straw. Several other studies are underway in the eastern United States and Canada, all of which focus on the use of cereal straw for particleboard.

Samples of this particle board were produced at the Washington State University (WSU) Wood Materials and Engineering Lab (refer to attachment B). The particle board panels were produced by using Kentucky bluegrass, cereal grain straw, and combinations thereof. Mike Wolcott, an Associate Professor and wood composite specialist at WSU conducted the sample studies. Mr. Wolcott provides much of the technical expertise and background for our study.

At this time a Phase I Study has been completed (see attachment A). This study involved the following:

PHASE ONE:

- 1.1) Develop an Overall Project Design and Literature Search
- 1.2) Conduct a Market Analysis for Strawboard
- 1.3) Conduct Straw Volume Evaluation
 - Biomass Volume Assessment
 - Harvest/Handling Procedures
 - Producer Survey Design
 - Procurement Parameters
- 1.4) Conduct a Straw Assessment
- 1.5) Final Report

3. Project Objectives

PHASE TWO: proposed project objectives

- 2.1) Conduct Producer Survey
- 2.2) Conduct Fiber Evaluation
- 2.3) Conduct Laboratory Panel Testing and Sample Production
- 2.4) Evaluate Equipment and Plant Concept Design
- 2.5) Determine Environment Outcomes of Fiber Production
- 2.6) Produce Financial Forecasts
- 2.7) Produce Final Report.
- 2.8) Coordinate Public Education and Information Dissemination

4. Approach: Materials and Method

Phase One: <Completed>

Report: Kentucky Bluegrass Post-Harvest Straw-based Particleboard (attachment A)

Phase Two:

Proposed Project Objectives:

- 2.1) Conduct Producer Survey: (Completed)** As designed in Phase 1, a farmer questionnaire will be mailed to a selected number of grass and grain growers in the region. Such a survey can assist in the development of possible straw procurement scenarios and can help define farmer attitudes and price expectations. The report from this survey will include analytical analysis and detailed responses, depicted in both chart and table formats. General conclusions will be considered through input from other participants. **(See attachment B)**
- 2.2) Conduct Fiber Evaluation:** This will review the present impact of straw burning legislation in Washington and add a database component for Barley production in the Whitman/Latah county area.

- 2.3) **Conduct Laboratory Panel Testing and Sample Production:** Some straw panel samples have already been produced at the Washington State University Wood Materials and Engineering Lab for sample production. The specific lab program was determined in part by the results of the Phase 1 raw material and marketing analysis. The purpose of the samples was to provide a quantity of panels for physical property analysis. Lab analysis included modulus of rupture, modulus of elasticity, internal bond, density and thickness swell tests. Lab samples produced to date involved bluegrass and a bluegrass/wheat straw combination (in layers). Some further tests will involve a wheat/barley/bluegrass blend of fiber to determine compatibility and panel properties. This phase will result in a detailed lab report on the panel analysis and a quantity of small presentation samples.
- 2.4) **Evaluate Equipment and Plant Concept Design:** Preliminary engineering designs for equipment, buildings and site development will be conducted, including the identification of those elements of process equipment which can be provided by local suppliers. This phase will develop rough order of magnitude cost estimates for a typical straw particleboard manufacturing facility, based on the operating parameters identified in the previous sections. All designs will be of sufficient detail, including capital budget estimates to provide any potentially interested developer with a basis for decision-making. In addition, a preliminary engineering review of environmental regulations will be conducted, sufficient to identify areas of compliance that a straw-based particleboard operation would need to understand and implement. In the case of bluegrass straw, substantial considerations of the impact of straw removal and field burning will be included. This phase will result in a series of equipment schematics, building and site plan drawings and general capital cost estimates for budget purposes. A list of environmental compliance criteria will also be included.
- 2.5) **Determine Environmental Outcomes of Fiber Production:** Develop a database to evaluate the impact of straw removal from the proposed facility of the feasibility study. This will be directly related to the impact of the amount of straw removed for this process to the reduction of particulate and gas emissions from field burning.
- 2.6) **Produce Financial Forecasts:** Based on the study components, a detailed set of working assumptions will be developed, upon which five-year operating forecasts will be produced. These will include a monthly forecast for a year one start-up period, with annualized financial forecasts including income and expense, balance sheet and cash flow statements. In addition, a specific capital cost schedule will be included, as well as amortization tables and key ratio summaries. A series of sensitivity analysis will also be included, which will reflect any identified deviations from the basic assumption scenario.
- 2.7) **Produce Final Report:** The completed analysis will result in a Final Report formatted as a comprehensive business development plan for a potential straw-based particleboard plant in the Palouse region.
- 2.8) **Coordinate Public Education and Information Dissemination:** We propose to approach other interested groups, such as port districts, agricultural associations and other citizen groups to join with our organization to evaluate and determine the feasibility of this project.

5. *Refer to D: Budget and Justification, page 5*

D. BUDGET AND JUSTIFICATION

PHASE ONE

#	Objective	Cost	Timetable	Pending \$'s
1.1	Develop an Overall Project Design and Literature Search	\$2,000.00	COMPLETED	FULLFILLED
1.2	Conduct a Market Analysis for Strawboard	\$4,000.00	COMPLETED	FULLFILLED
1.3	Straw Volume Evaluation	\$2,000.00	COMPLETED	FULLFILLED
1.4	Straw Assessment	\$3,000.00	COMPLETED	FULLFILLED
1.5	Final Report	\$4,000.00	COMPLETED	FULLFILLED
	TOTAL PHASE ONE	\$15,000.00		

PHASE TWO: Assuming startup date of March 15, 1998

#	Objective	Cost	Timetable	Pending \$'s
2.1	Conduct Producer Survey	\$3,000.00	COMPLETED	FULLFILLED
2.2	Conduct Fiber Evaluation	\$1,750.00	May 1, 1998	\$1,750.00
2.3	Conduct Laboratory Panel Testing and Sample Production	\$5,750.00	June 1, 1998	\$5,750.00
2.4	Evaluate Equipment and Plant Concept Design	\$3,750.00	June 20, 1998	\$3,750.00
2.5	Determine Environmental Outcomes of Fiber Production	\$1,500.00	July 1, 1998	\$1,500.00
2.5	Produce Financial Forecast	\$1,750.00	Aug. 1, 1998	\$1,750.00
2.6	Produce Final Report	\$3,000.00	Aug. 10, 1998	\$3,000.00
2.7	Public Education and Information Dissemination	\$5,000.00	Dec. 1, 1998	\$5,000.00
	TOTAL PHASE TWO	\$25,500.00		
	TOTAL AMOUNT REQUESTED			\$22,500.00

E. REFERENCES: Refer to Cite Sheet in Phase I Report, Attachment A

F. CURRENT AND PENDING SUPPORT: Refer to D: Table

Keith Kopf

Employment

1997 – 1998

President / Co-Owner, Sun Straw Fiber L.L.C

Pullman, WA

1997 – 1998

Co-Partnership, Keith Kopf L.L.C.

Pullman, WA

1979 – 1998

Owner-Operator of Farm, Corporation, 4400 Acres

Pullman, WA

- Supervisor Shop Personnel
- Office Manager-Bookkeeper-Contracting
- Machine Maintenance
- Manage Pesticide-Fertilizer Application
- Government Farm Plans
- Crop Management
- Marketing

1970 – 1979

Manager of Family Farm, 1700 Acres

Pullman, WA

- Supervisor Shop Personnel
- Machine Maintenance
- Manage Pesticide-Fertilizer Application
- Government Farm Plans
- Crop Management

1976 – 1977

Valley Cement, Asphalt Plant Manager

Pullman, WA

- Supervisor – Managing Operations, Machine Maintenance

Education

1970 - 1974 Pullman High School Pullman, WA

General Studies

- 4 years vocational agriculture
- 2 years FFA president

Professional memberships

Whelan Grange, WA Association of Wheat Growers, National Federation of Independent Businessmen, Whitman County Property Owners Association, Palouse Conservation District (supervisor).

Mark Whitmore

Employment	1997 – PRESENT	Sun Straw Fiber L.L.C.	Pullman, WA
	Vise President / Co-Owner		
	1987 – PRESENT	Whitmore Farms	Pullman, WA
	Owner/Operator of 1200 acre farm		
	<ul style="list-style-type: none">▪ Manager▪ Shop Foreman▪ Safety Officer▪ Field Operations Manager		
Education	1980 – 1987	Whitmore Farms	Pullman, WA
	<ul style="list-style-type: none">▪ Assistant Manager▪ Operations Manager		
	1979 – 1980	McKeiman Brothers	Pullman, WA
	<ul style="list-style-type: none">▪ Serviceman		
Professional memberships	1974 - 1978	Pullman High School	Pullman, WA
	General Studies		
	<ul style="list-style-type: none">▪ 4 years vocational agriculture▪ 2 years business and accounting▪ 1 year foreign language		
	1978 – 1980	Spokane Community College	Spokane, WA
	<ul style="list-style-type: none">▪ Diesel and heavy equipment mechanics▪ First-Aid▪ Advanced welding▪ Accounting		
Volunteer experience	Pullman High School FFA, Grange		
References	Mike Whitman	Grower	Pullman, WA
	Steve Mader	Grower	Pullman, WA

Jon Booker

Employment

1997 – Present Sun Straw Fiber, L.L.C. Pullman, WA
Secretary / Chairman / Co-Owner

1988 – present Wilbur-Ellis Company Pullman, WA
Assistant Manager-Salesman/ Certified Crop Advisor

- Supervisor for shop personnel
- Regulatory officer
- Safety officer
- Office manager
- Specialty crop agronomist
- Soil test analyst
- Fertility and pesticide recommendations
- Crop Scouting
- Sales
- Fertilizer and chemical delivery

June 1998 – September 1988 Fred Zimmerman Farms Oakesdale, WA

- Grain truck driver / Combine operator

August 1997-June 1988 Alcoa Wenatchee, WA

- Intern in accounting department

June 1984-June 1988 D & J Grain Sales Malaga, WA

- Owner / Operator

Education

1984 – 1988 Wenatchee High School Wenatchee, WA

General studies

- 4 years vocational Agriculture
- 3 years Spanish
- 3 years business and accounting
- 1 year business law

1988-1989 Washington State University Pullman, WA

- Agricultural Economics

References

Alan Martinson Manager, Wilbur-Ellis Company Pullman, WA

Fred Bierwagen Business Unit Manager, Wilbur-Ellis Company, Pasco, WA

Professional memberships

National Certified Crop Advisor Program, Washington Association of Wheat Growers, Moscow Chamber of Commerce, Pullman Chamber of Commerce, Whelan Grange, Pullman FFA Alumni, PNW Precision agriculture committee and PNW Direct Seed Conference

C. William ("Bill") Russell

AGB Technologies, Inc.
3206 - 25th Avenue
Regina, Saskatchewan, Canada
306/721-3382
e mail: agbtech@sk.sympatico.ca

In 1986, Bill Russell began conducting extensive research in the development of particleboard from wheat straw for the Saskatchewan Department of Agriculture. He has since completed several technical and development studies related to the conversion of a variety of cereal and oil seed crop residues, grass straw, and mixtures of straw and residue wood fibers from both softwood and hardwood sources.

Bill has developed a unique expertise in the analysis of straw procurement issues and residual fiber utilization. He has conducted specific evaluations across the Canadian wheat belt as well as the US mid-west and Inland Empire, consulting in both agricultural and forest-related fiber studies.

With marketing experience in the United States and Canada, Bill has developed a product development strategy based on existing and forecast market demands. In addition, he has a thorough working knowledge of technical laboratory testing, engineering design, and economic forecasting.

Bill has held memberships in the Forest Research Society, the Particleboard/MDF Institute, the New Uses Council, and the National Association of Wheat Growers. He has participated as a delegate and speaker at the annual International Composite Materials Symposium, held at Washington State University in Pullman, Washington, since 1986.

RELATED PROJECTS

Strategic Market Study – Cabinet Manufacturing

Development of expansion plan for cabinet manufacturer; included specific analysis of regional retail activity; detailed financial projections and sensitivity analyses; development of strategic expansion model. (1981)

Strategic Planning – Integrated Forest Products Development

Conducted comprehensive plan for multi-product lumber mill; developed working Boreal forest model for both coniferous and deciduous production; developed long-term harvest, environmental, manufacturing, and marketing objectives; forecast sustainable revenues and operating proformas. (1986)

Straw Particleboard – Preliminary Feasibility Evaluation

Designed to determine viability of future research; provided the foundation for government funding; identified a range of preliminary technological questions; assessed rural development potential. (1986)

Straw Particleboard (Phase 1) – Technical Analysis

Conducted major government evaluation for straw particleboard development; included straw and soil considerations; production and testing procedures; market analysis; rural economic implications. (1987)

Engineering and Marketing Analysis – Straw Particleboard (Phase 2)

Focused on (1) compact plant/equipment technology, and (2) market response to strawboard furniture. Involved review of equipment manufacturers, with on-site interviews and engineering inspections in Europe and North America; produced straw panels, manufactured sample furniture items which were used in consumer focus groups. (1989)

Residue Research and Commercialization Study – Alberta Forestry

First study of its kind in Canada; included data base development; 21 on-site mill and woodland interviews; historical overview of North American residue management; quantification of residual fiber volumes from mill types, equipment types, and species types; identification of potential conversion opportunities including pulp, particleboard, and ethanol; conducted general engineering and financial forecasts on conversion processes. (1990)

Feasibility Analysis - Straw Particleboard Manufacturing Plant

Conducted feasibility study for mid-west cabinet manufacturer; involved straw availability and farmer survey, site selection; identified potential MDF applications; product development including lab trials, equipment design, and detailed financial forecasting; findings used to determine specific plant development plan. (1994)

Laboratory Production – Straw Particleboard Samples for Furniture Trials

Produced large quantity of lab panels (36" x 48") for leading mid-west furniture manufacturer, designed to provide basis for furniture factory trials; involved development of potential low-density/high-strength applications. This was largest lab run of strawboard ever conducted in North America. (1995)

Feasibility Study - Regional Straw Particleboard Manufacturing Potential

Feasibility analysis for potential southeast Idaho straw particleboard development; involved straw supply, marketing, farmer survey, plant design, and financial forecasts; used to form basis of business development plan which is currently being reviewed for funding. (1995)

Straw Utilization Analysis -- Kentucky Bluegrass

In conjunction with Washington State Department of Ecology and Washington State University, conducted feasibility analysis of potential volumes of bluegrass straw particleboard development; involved straw supply database development in Eastern Washington and Northern Idaho, marketing analysis, design of farmer survey questionnaire. Designed as the first phase of a two-phase feasibility study. Some rudimentary lab analysis was also conducted as a secondary component of the study. (1996)

Strategic Feasibility Analysis - Straw Particleboard Manufacturing

Feasibility analysis for potential Northcentral Montana strawboard development; involved a seven-county straw analysis, marketing assessment, farmer survey, plant design, and financial forecasts; used to form basis of business development plan which is currently being reviewed for funding. (1997)

Symposia, Conferences, and Memberships

Canadian Forestry Service Mixedwood Symposium (Speaker)

- Edmonton, 1988. Presented paper entitled "Wood Products Marketing: Can the Old Dog Learn New Tricks?", discussing existing and potential non-traditional products from cellulose (wood and non-wood) fibers.

Forest Products Society

- Member, 1987 - Present

First International Straw Conference (Speaker)

- Copenhagen, Denmark, 1991. Developed paper on "The Use of Agricultural Residues for Industrial Particleboard".

International Particleboard Symposium

- Annual conference sponsored by Washington State University; international conference on particleboard and composite panels is the leading symposium of its kind in the industry. Delegate from 1987 to 1997.

International Particleboard Symposium – Technical Forum (Presenter)

- Presented technical poster entitled "Straw for Particleboard" at forum sponsored by Forest Products Research Society, during 1991 WSU symposium.

Canadian Association of Flax Growers (Speaker)

- Regina, Saskatchewan, 1991. Presented paper on "The Use of Flax and Linen Fiber for Reconstituted Panel Production".

Biobased Products Expo '94

- Kansas City, Missouri, 1994. Delegate to conference on expanding industrial uses and markets for agricultural and forestry materials.

New Uses Council, Inc.

- Member, 1994 to present.
- Kansas City, 1994. Delegate to national conference on moving agriculture beyond basic food and fiber uses.
- Boise, Idaho, 1995. Delegate to regional working session to develop platform for 1995 Farm Bill.

Wheat Utilization Summit

- Kansas City, 1994. Delegate to National Association of Wheat Growers conference on "Building Demand Through New Uses".

National Association of Wheat Growers

- Member, 1994 to present.

Particleboard/MDF Institute

- Member, 1994 to present.

Laminating Materials Association – 1995 Annual Meeting (Invited Speaker)

- New Orleans, 1995. Invited to present paper (untitled) on the theoretical and practical implications of laminating on non-wood substrates; to be co-presented with furniture manufacturer.

International Particleboard Symposium – (Speaker)

- Pullman, WN, 1996. Presented conference paper entitled "The Straw Resource: A New Fiber Basket?" at 30th Annual WSU symposium.

Oregon Wheat Growers League – (Speaker)

- Portland, OR, 1997. Presented conference paper entitled "The Potential of Using Straw for Industrial Fiberboard"; sat on panel discussion with agricultural co-operative groups from North Dakota, Kansas..

Appendix A

CERTIFICATIONS AND ASSURANCES

I/we make the following certifications and assurances as a required element of the bid or proposal to which it is attached, understanding that the truthfulness of the facts affirmed here and the continuing compliance with these requirements are conditions precedent to the award or continuation of the related contract(s):

1. The prices and/or cost data have been determined independently, without consultation, communication or agreement with others for the purpose of restricting competition. However, I/we may freely join with other persons or organizations for the purpose of presenting a single proposal or bid.
2. The attached proposal or bid is a firm offer for a period of 60 days following receipt, and it may be accepted by the Department of Ecology without further negotiation (except where obviously required by lack of certainty in key terms) at any time within the 60-day period.
3. In preparing this proposal or bid, I/we have not been assisted by any current or former employee of the State of Washington whose duties relate (or did relate) to this proposal, bid or prospective contract, and who was assisting in other than his or her official, public capacity. Neither does such a person nor any member of his or her immediate family have any financial interest in the outcome of this proposal or bid. (Any exceptions to these assurances are described in full detail on a separate page and attached to this document.)
4. I/we understand that the Department of Ecology will not reimburse me/us for any costs incurred in the preparation of this proposal or bid. All proposals or bids become the property of the Department, and I/we claim no proprietary right to the ideas, writings, items, or samples.
5. I/we understand that any contracts awarded as a result of this RFP will contain terms and conditions substantially similar to those attached as Appendix B. I/we certify that I/we will comply with these or substantially similar Terms and Conditions if selected as a contractor.

Signature

2/9/98

19

PRESIDENT
Title

Attachment B

Whitman County Straw Survey Results

Whitman County Straw Survey Results

The following pages include the question-by-question results of the farmer survey conducted in Whitman County, Washington in April and May, 1997.

PURPOSE

The overall purpose of this strawboard study is to determine the feasibility of a particleboard manufacturing facility in the Palouse area which would convert regional agricultural residues – namely wheat, barley, and bluegrass straw – into industrial particleboard.

A major component of this study involves the determination of farmers' interest in providing a sufficient quantity of straw, how their present farming practices might impact the removal of straw, and some idea of pricing, baling and procurement expectations.

SURVEY METHODOLOGY

As part of a Phase One study conducted in co-operation with the Crops and Soil Sciences Department of Washington State University and the Washington Department of Environment, a questionnaire was developed consisting of 21 questions, covering general matters and specific questions relating to loose straw, baled straw, custom baling and hauling. A draft of the questionnaire was provided to an advisory group representing various areas of interest, including several area farmers. Input from these sources was helpful in targeting the questionnaire toward specific farmer expectations.

Mailing lists from a regional farm service organization were utilized for distribution. The questionnaire was included in a Whitman County-wide newsletter.

RESPONSE

A total of 172 questionnaires were returned, representing a substantial response given the broad distribution manner.

QUESTION 1: How many acres of the following crops did you harvest in the past four years?

Respondents indicating acreages for wheat and barley for the various years are as follows:

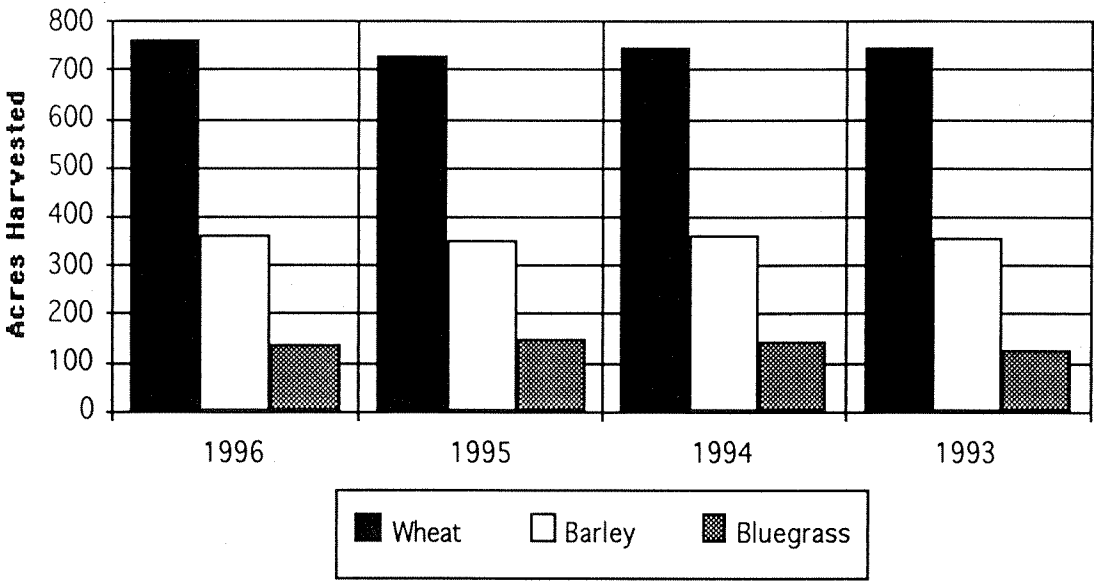
1996	Wheat	156	1995	Wheat	158
	Barley	133		Barley	131
	Bluegrass	26		Bluegrass	22
1994	Wheat	161	1993	Wheat	146
	Barley	131		Barley	126
	Bluegrass	20		Bluegrass	16

The average number of acres per respondent are as follows:

1996	Wheat	764	1995	Wheat	728
	Barley	362		Barley	352
	<u>Bluegrass</u>	<u>136</u>		<u>Bluegrass</u>	<u>145</u>
	Total	1,262		Total	1,225
1994	Wheat	746	1993	Wheat	746
	Barley	360		Barley	358
	<u>Bluegrass</u>	<u>141</u>		<u>Bluegrass</u>	<u>125</u>
	Total	1,247		Total	1,229

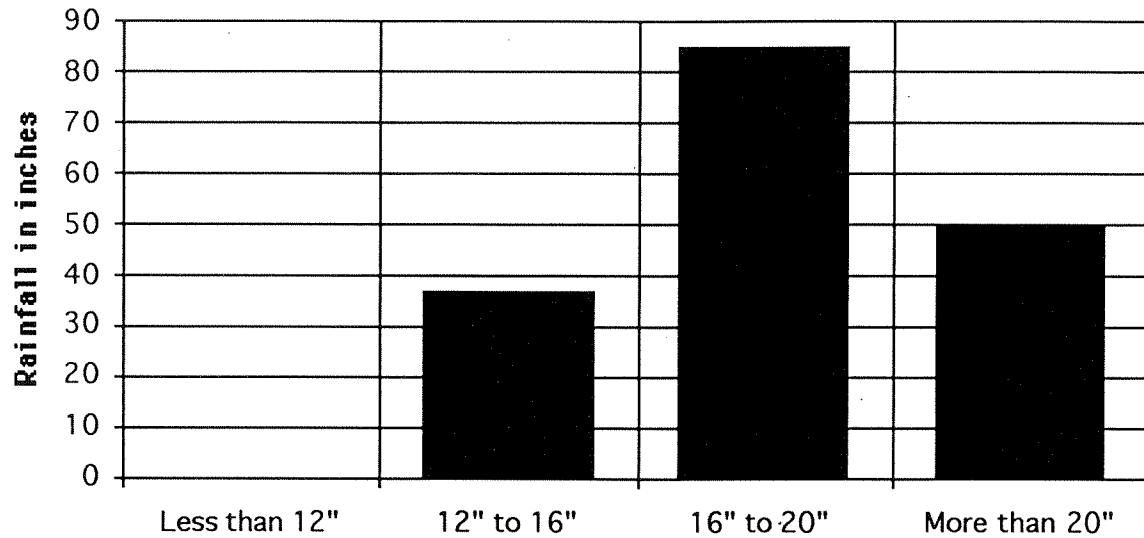
Barley acreage averaged approximately 29% of the total acreage, while the average acreage for bluegrass was approximately 10% of the total acres. Wheat accounted for the balance, at 61%.

Question 1, continued



QUESTION 2: What is your normal annual rainfall?

Average annual rainfall is a major determinant in planning for not only crop yields year after year, but also the techniques and methods used in gathering and storing straw.



**QUESTION 3: What is your normal practice in handling loose straw
after harvest?**

This question represents a critical area for a prospective straw user, as the present practice of farmers with respect to their handling of straw provides a key indicator of potential sustainable volumes.

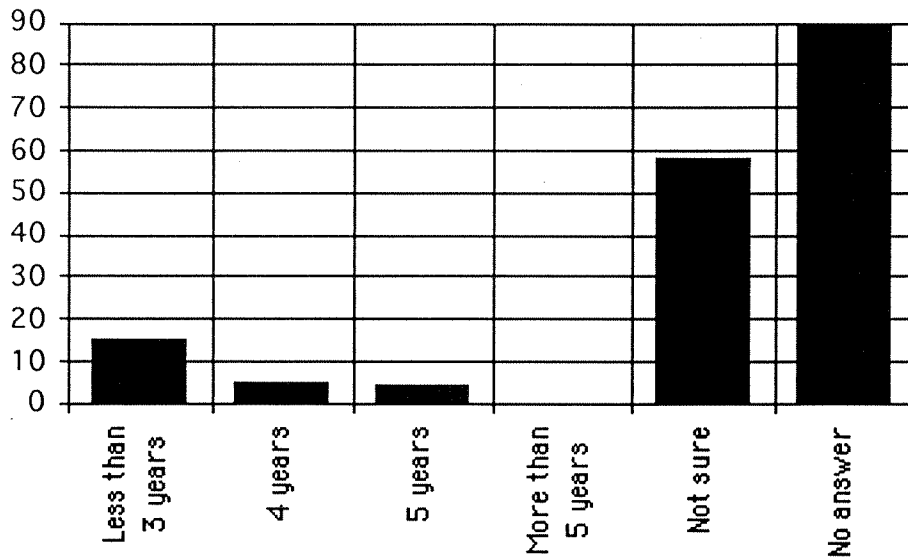
The results below represent the percentage of respondents who indicated *some activity* in the relevant handling practice for wheat and barley straw:

Till into soil.....
Bale for own use
Bale for sale to others
Burn in the field.....
Other

(Results being retabulated)

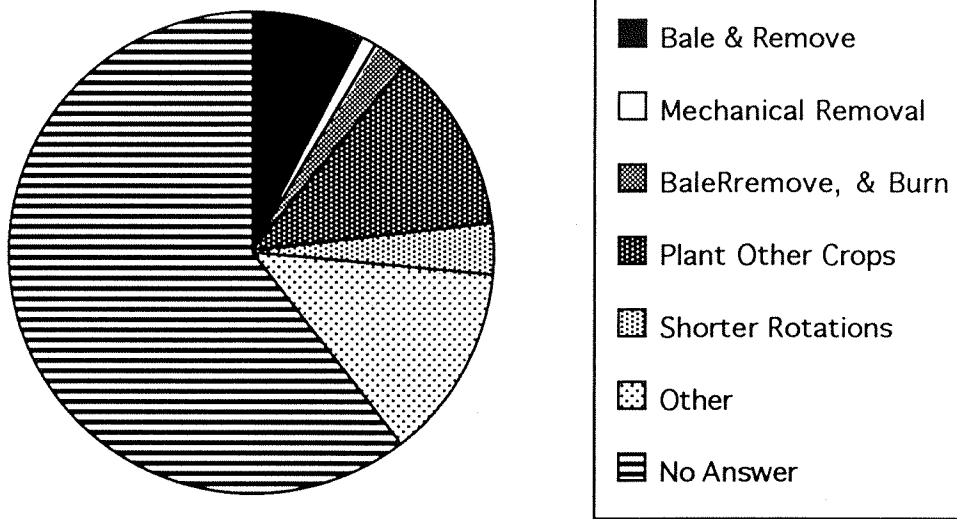
QUESTION 4: How long do you keep your bluegrass crop in?

With the present uncertainty surrounding the viability of the bluegrass industry, this question was designed to provide some indication of producer expectations concerning their own involvement in growing bluegrass.



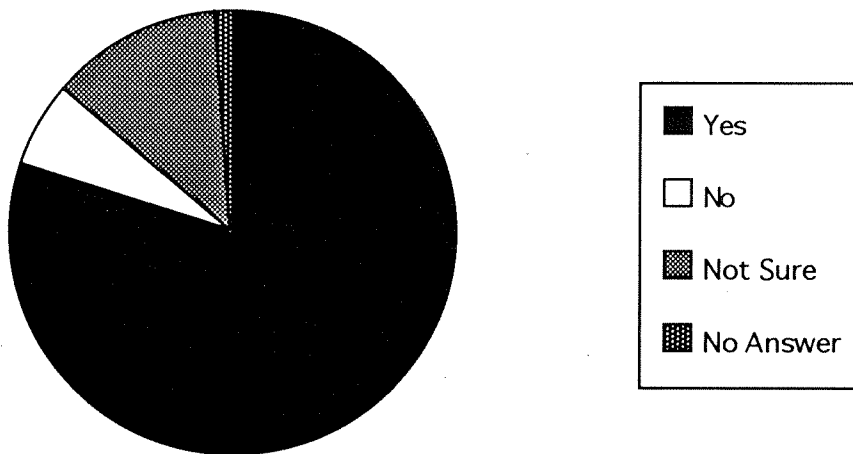
QUESTION 5: If burning bluegrass straw is removed as a management tool, what do you feel would be your options?

This largest number of responses to this question was "No Answer", indicating the current level of transition in the industry.



QUESTION 6: If there was a commercial market for straw, would you be interested in selling your straw in the field if someone else (e.g. a custom baler) baled and removed it?

This is another key question for purposes of forecasting potential sustainable straw volumes. All but two respondents completed this question, and 80% indicated a willingness to sell their loose straw. Only 6% said "No" to this question, while 12% answered "Not Sure".



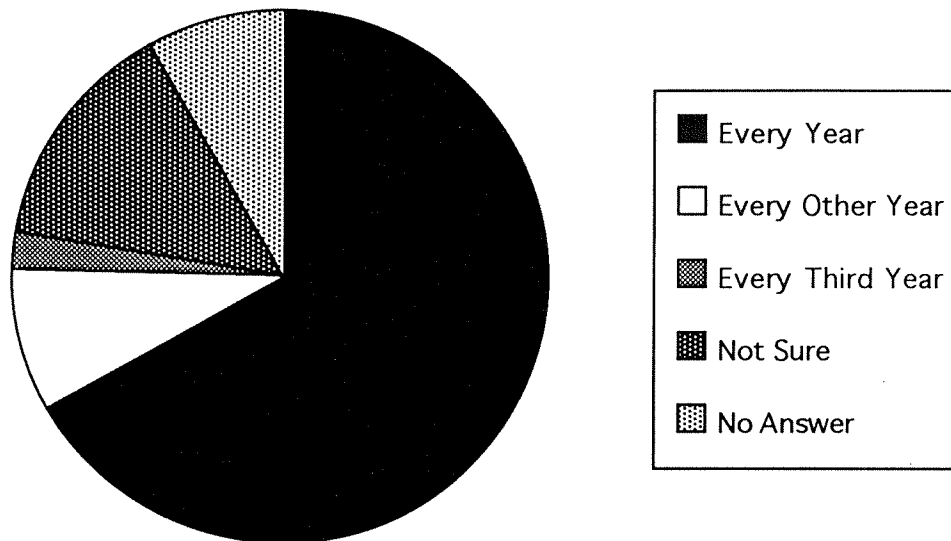
QUESTION 7: How many acres of loose straw would you be willing to sell?

The response to this question showed that on average, the respondents would sell straw from approximately 278 acres. The high response was 2,000 acres, while the lowest response was 10 acres.

(Further data to be supplied pending re-formatting.)

QUESTION 8: If you answered “yes” to question 6, how frequently would you sell your straw?

Of those who responded to this question, approximately 67% indicated they would sell straw every year; the next largest group of respondents where *not sure* how frequently they would sell their straw (14%). A total of 11% indicated they would sell straw every two or three years.



QUESTION 9: What do you feel would be a fair price for your loose straw?

Another key question, and one which reflects the greatest variations of responses. Only 60% of those who sent in surveys responded to this question, indicating some uncertainty among growers as the value of the straw in the field.

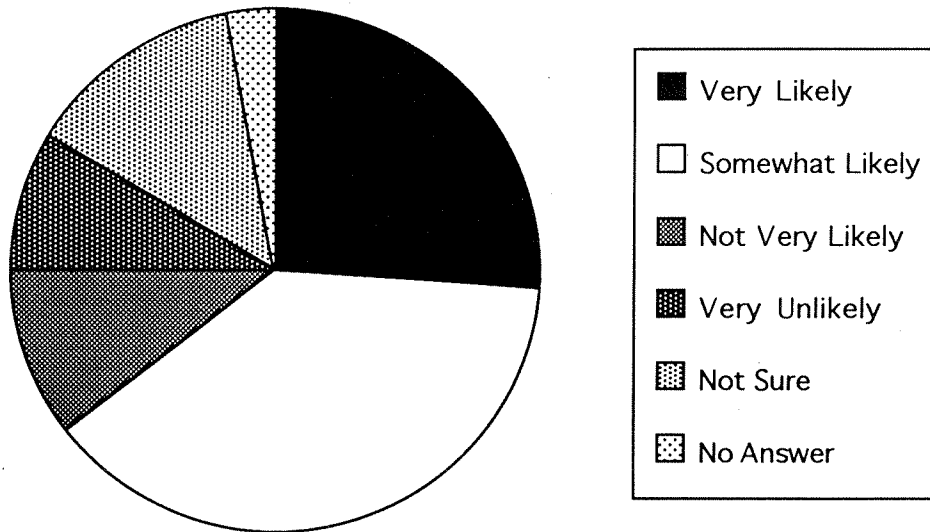
The breakdown of responses, in dollars per ton, is as follows:

\$0-5	2
\$6-10	15
\$11-15	11
\$16-20	27
\$21-25	15
\$26-30	10
\$31-35	4
\$36-40	8
\$41-45	0
\$46-50	5
\$51-55	0
\$56-60	2
\$60+	4
Total.....	103

The average of these responses is \$26.17 per ton. Eliminating the responses over \$60, and those under \$5, the median price is \$30.

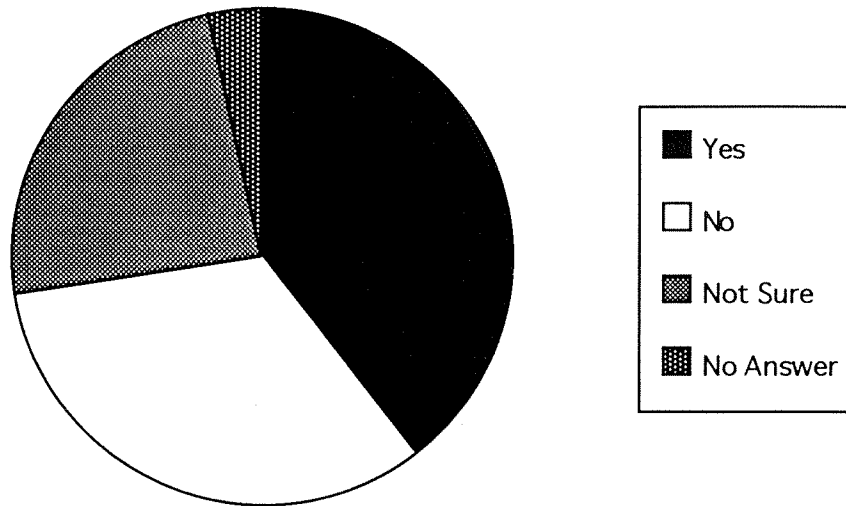
QUESTION 11: How likely would you be to sign a long term contract (e.g. 3-5 years) to supply a specified number of acres to a commercial user?

The majority of respondents (64.5%) indicated they would be “somewhat likely” or “very likely” to sign a long term contract. Only 9% were “very unlikely” to sign a contract.



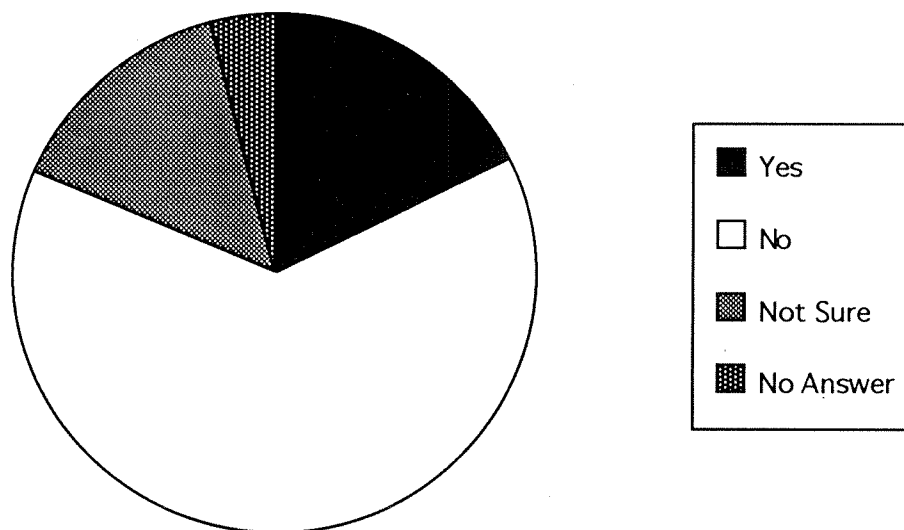
QUESTION 12: Would you be interested in baling your own straw?

The option to bale or not to bale is closer than may responses in the survey, with 40% responding "Yes" and 33% answering "No". An additional 24% were not sure.



QUESTION 13: Would you be willing to store baled straw on your land on a temporary basis (e.g. 6 months)?

This is another key question, as it is unlikely that all the straw required by a particleboard plant could be stored in one location. Only 18% indicated they would be willing to store bales on their land, while 63% said "no". A further 19% indicated they were either "Not Sure" or did not answer.



**QUESTION 14: What do you feel would be a fair price for your straw, if
you sell it and bale it yourself?**

The breakdown of responses, in dollars per ton, was as follows:

\$0-5	1
\$6-10	2
\$11-15	1
\$16-20	3
\$21-25	0
\$26-30	4
\$31-35	4
\$36-40	13
\$41-45	1
\$46-50	13
\$51-55	1
\$56-60	3
\$61-65	0
\$66-70	2
\$71-80	4
\$81-90	0
\$91-100+	2
Total.....	54

The average of these responses was \$24.13 per ton of baled straw (less than the cost for loose straw in Question 6!). Eliminating the highest and lowest responses, the median price was \$45.00.

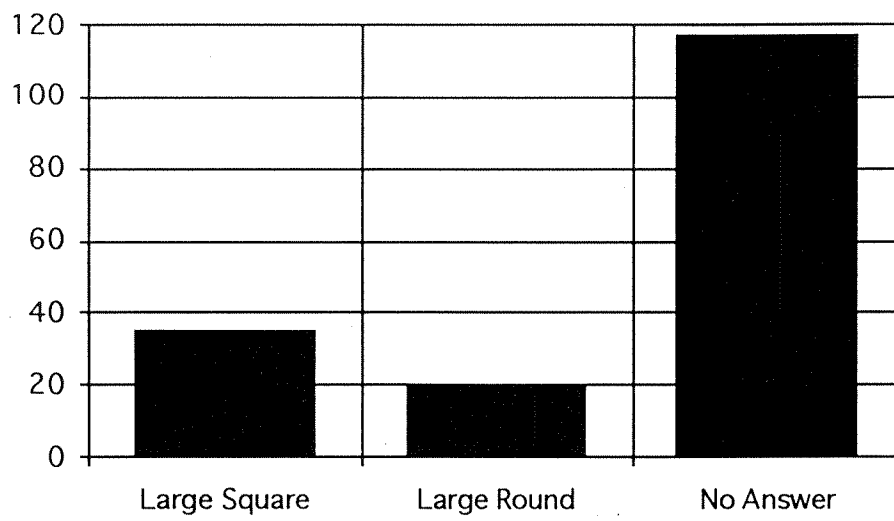
QUESTION 15: How many acres would you be willing to bale for sale?

A the respondents who completed this question, the total response reflected an average acreage per respondent of 129 acres.

The actual responses are as follows:

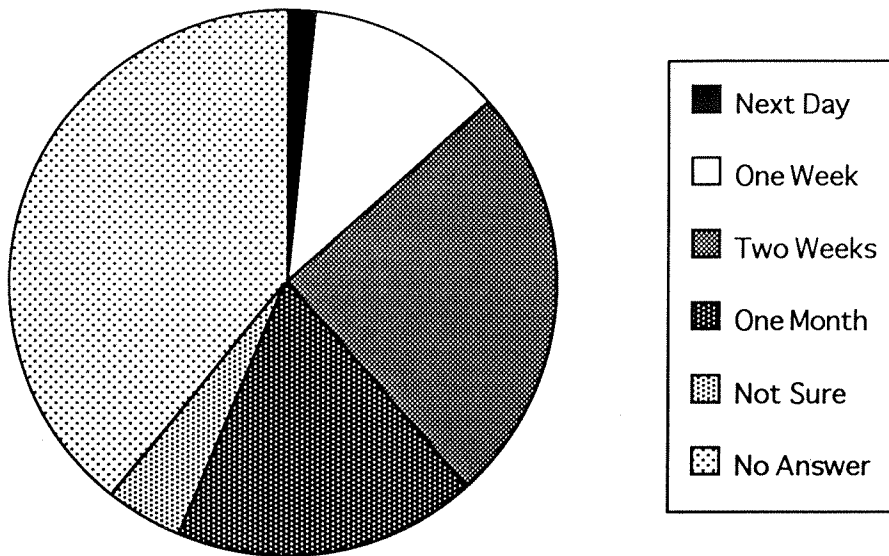
0-100 acres	18
101-200 acres	14
201-300 acres	7
301-400 acres	7
401-500 acres	2
501-600 acres	1
601-700 acres	0
701-800	1
801-900	1
901-1000	1
1000 +	1
Total.....	36

QUESTION 16: What type of baler would you use?



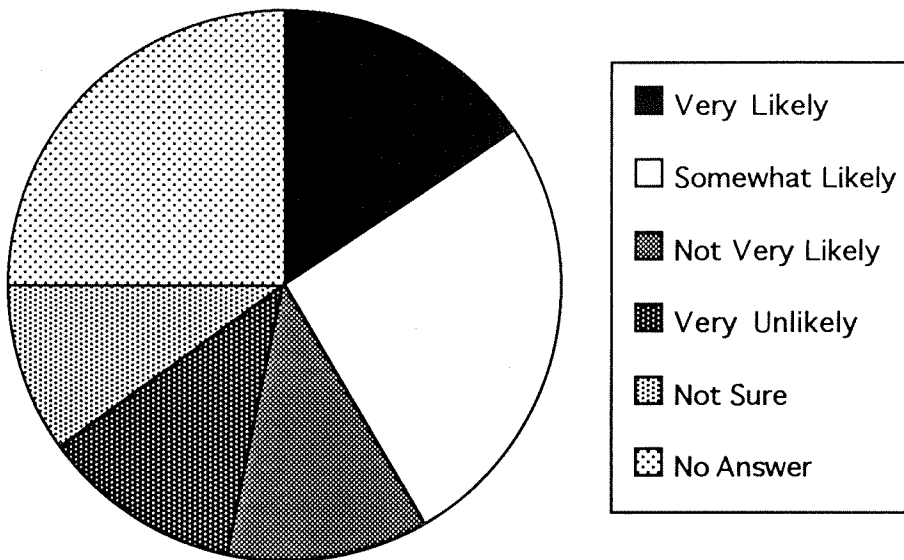
QUESTION 17: How soon after baling would you need the baled straw to be removed from the field?

A total of 53% indicated that bales would need to be removed between two to four weeks after baling. Fourteen percent (14%) indicated that bales would need to be removed sooner than two weeks.



QUESTION 18: How likely would you be to sign a long term contract (e.g. 3-5 years) to supply baled straw to a commercial user?

Approximately 42% indicated they would be *very likely* or *somewhat likely* to sign a long term contract. Twenty-four percent (24%) are unlikely to sign a contract, while 35% are either "Not Sure" or did not answer.



QUESTION 19: In which of the following age groups are you included?

The breakdown of the responses is as follows:

Under 24.....	0
25-34	14
35-44	53
45-54	36
55-64	40
65+	26
No answer.....	3
Total.....	172

